

# Landscape Multidimensional Scaling

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1. Visualisation of multidimensional data
2. The concept of landscape multidimensional scaling
3. Landscape multidimensional scaling algorithms
4. Examples
5. Conclusions



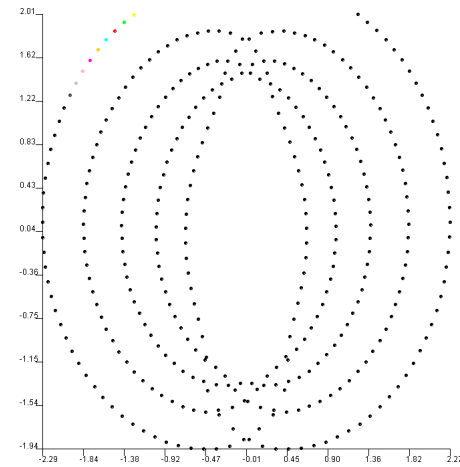
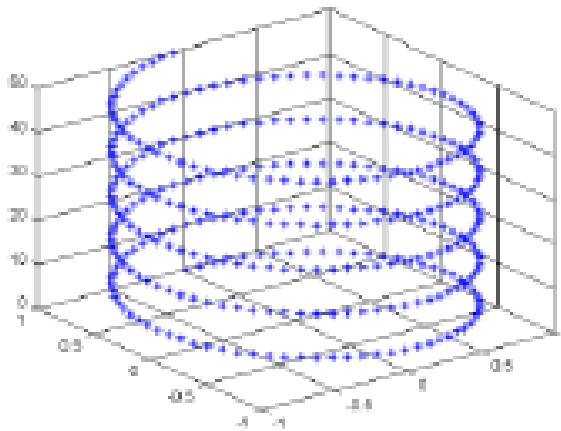
given: (multidimensional) data set  $X = \{x_1, x_2, \dots, x_n\}$  and

a symmetric distance matrix  $D = (d_{ij})_{1 \leq i, j \leq n}$  with

$d_{ij} > 0$  and  $d_{ii} = 0$

Scatter plot visualisation: Represent each  $x_i$  by a point in 2D or 3D preserving as much of the "information" of the original data space as possible.

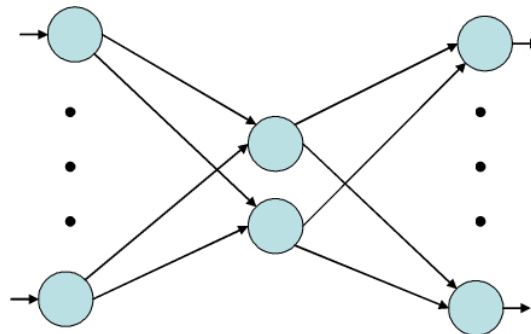
# 3D $\rightarrow$ 2D





preserving as much of the "information" of the original data space as possible:

- Principal component analysis: **variance**
- Autoassociative bottleneck neural networks: **functional reconstruction**



- Multidimensional scaling: **distance**

- non-linear optimisation problem
- initialise the points in 2D/3D randomly or by other techniques, e.g. PCA
- apply a gradient descent strategy to minimise the objective function

# Landscape multidimensional scaling



Use a suitable landscape to position the points instead of flat plane.

How to compute distances in a landscape?



# Landscape multidimensional scaling



Is this any better than standard 3D MDS?



# Landscape multidimensional scaling

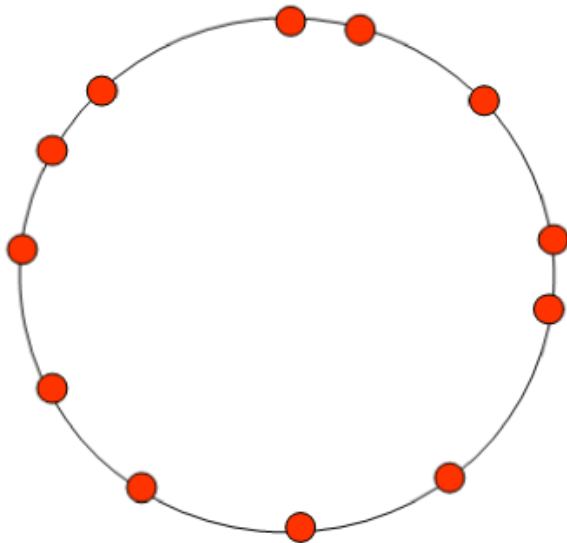


Is this any better than standard 3D MDS? **Yes, it is.**

# Landscape multidimensional scaling

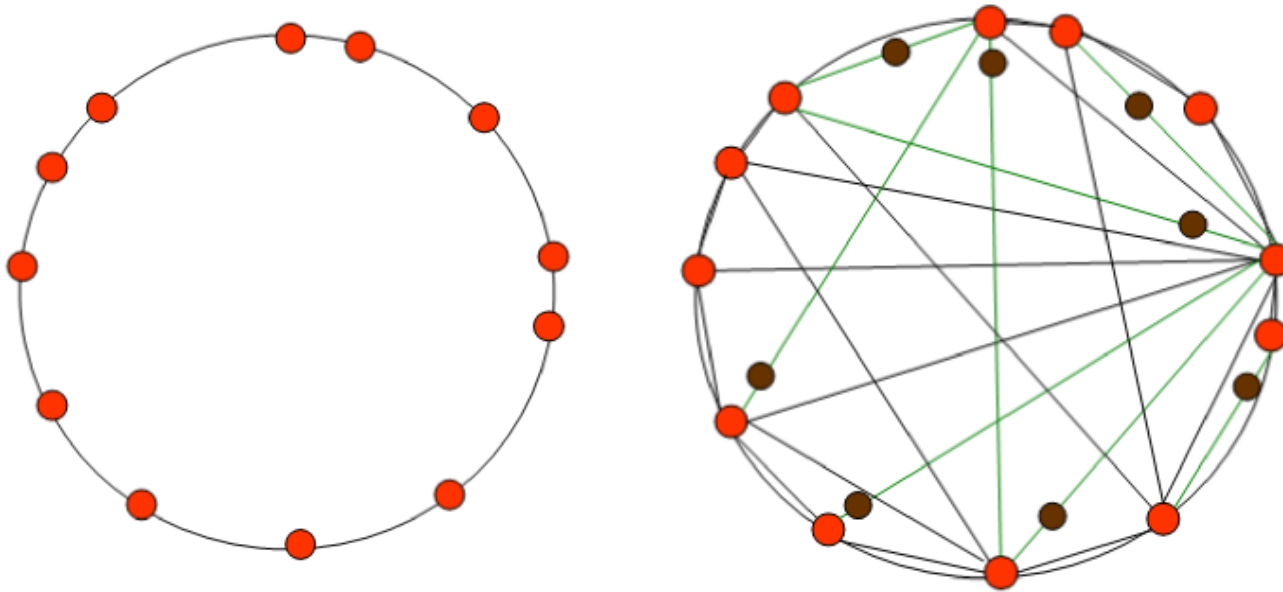


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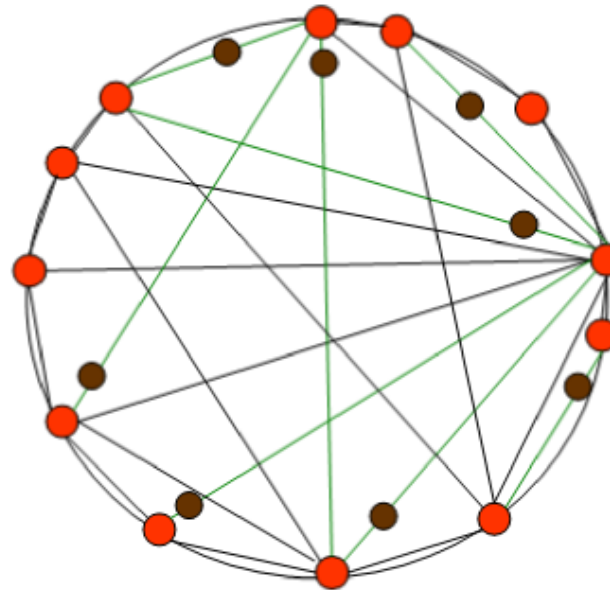
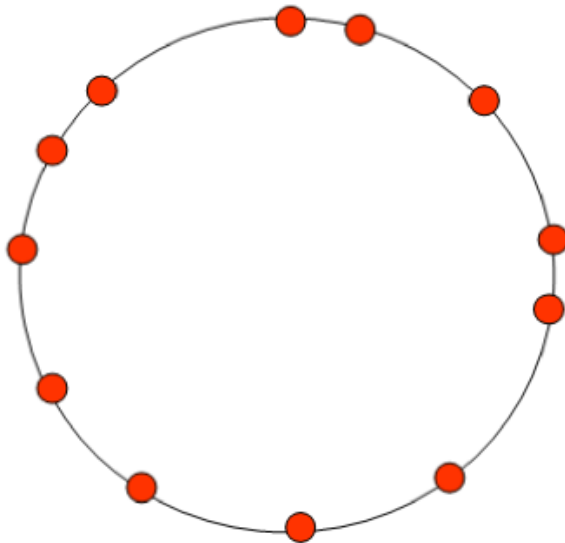


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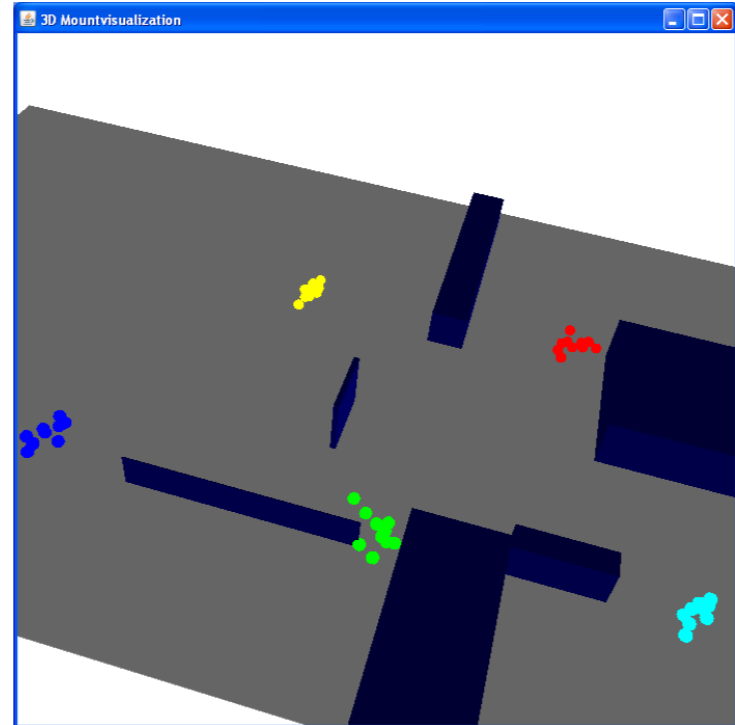
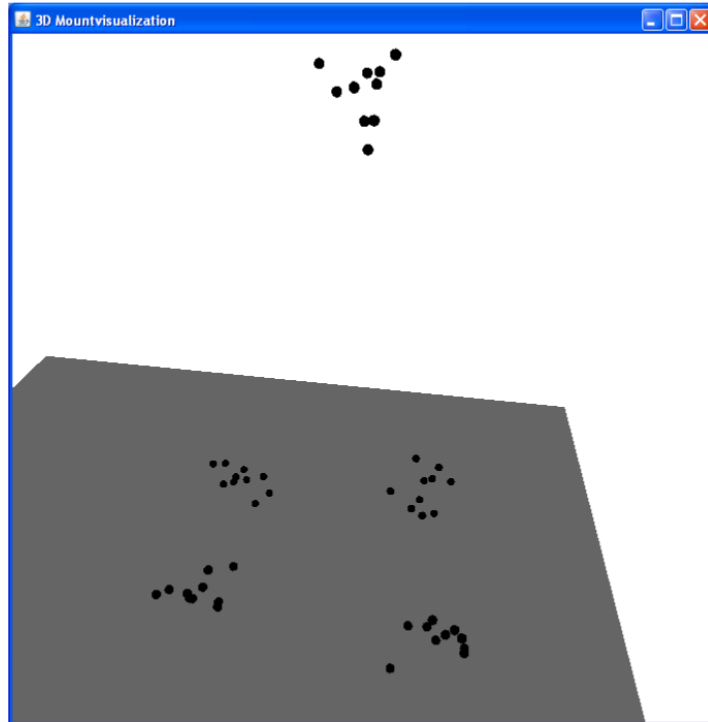
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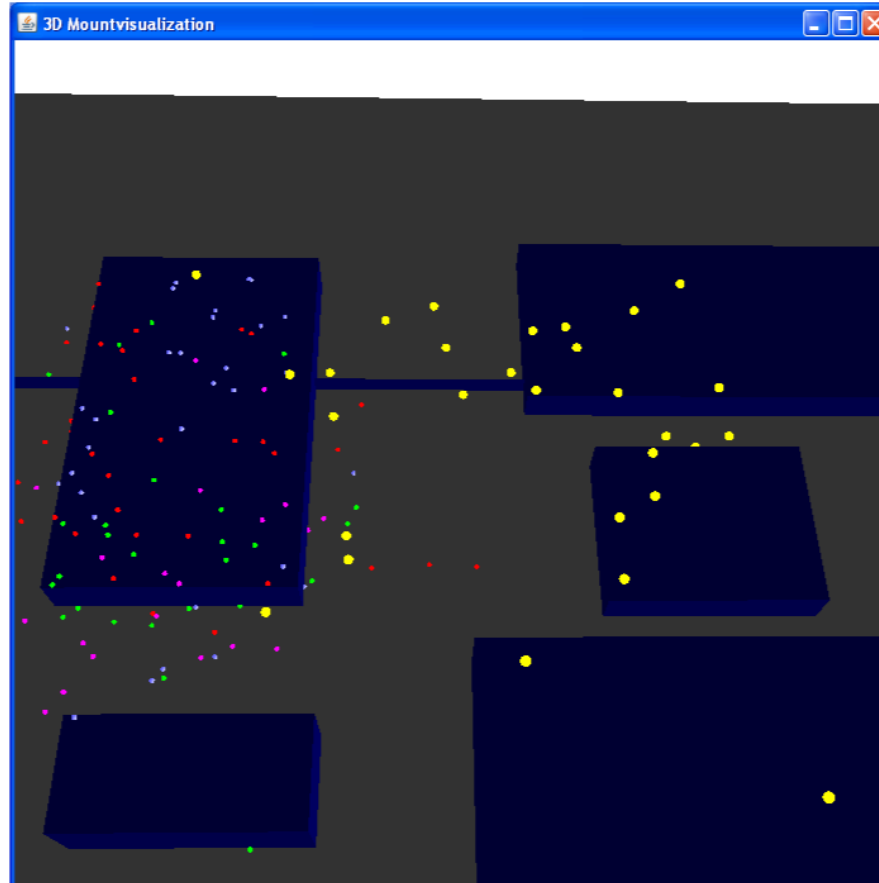
Error (stress): 0

1. Position the points in the plane preserving the distances or with smaller distances.
  - PCA
  - Constraint MDS
2. Introduce "mountains" (cylinders or boxes) into the landscape.
  - Positioning of the mountains by a brute force (evolutionary) algorithm.
  - Determining the heights of the mountains by an analytical solution.

# Examples



# Examples



- Optimal theoretical results, but not suitable for visualisation purposes.
- Often, but not always better than standard MDS.
- "Worm holes" would be better than mountains, but are not suitable for visualisation purposes.

